The location of this find is on a lot belonging to Mr. John Lebord, about one-half mile east of the intersection of the Woodside highway and the foothill road. It is in the plain formed by the coalescent alluvial fans that fringe San Francisco Bay. Physiographic evidence indicates that the entire deposit is of Recent and late Pleistocene age.

In this connection it may be of interest to recall that the depth and general position of the mastodon skeleton is about the same as that in which a human skull was found on the Stanford campus a few years previously.[2] The suggestion of contemporaneity is not to be lightly dismissed.

The tooth from this collection was submitted to Dr. W. D. Matthew, of the University of California, for examination. He found that it resembled rather closely the teeth of *Mastodon merriami* and *M. matthewi* Osborn—two species, of late Miocene and early Pliocene age, which have recently been segregated in a distinct genus, *Miomastodon*, by Dr. H. F. Osborn. As this genus is very imperfectly known the reference of the tooth to either of the above species can not be made with much confidence. The occurrence of the skeleton in the unconsolidated and entirely undeformed strata of the alluvial plain indicates strongly that the age is probably not greater than late Pleistocene. In that part of the California Coast Ranges all Pliocene formations have been strongly folded and faulted and even the early Pleistocene deposits have been disturbed and much eroded. The clear implication of the physiographic evidence is believed to be more significant in this case than the general resemblance of the teeth to those of a genus not yet known from post-Pliocene formations.

GEOLOGY.—*The Cretaceous section in Black Mesa, northeastern Arizona.*[1] JOHN B. REESIDE, JR. and ARTHUR A. BAKER, U. S. Geological Survey.

Black Mesa is an elevated area of Cretaceous rocks forming the central part of a well defined structural basin in northeastern Arizona. It constitutes a large part of the Hopi Indian Reservation in Navajo and Coconino Counties; on the northern and eastern sides it extends a short distance into the Navajo Reservation and therefore enters

[2] BAILEY WILLIS. *Out of the long Past.* Stanford Cardinal **32**: 8–11. 1922.

[1] Received December 18, 1928. Published with the permission of the Director, U. S. Geological Survey.

Apache County also. The geology of the mesa is of particular interest because it is one of the areas composing the westernmost line of deposits of the Cretaceous of the Interior Province. During the summer of 1928 the writers had opportunity to see much of the southern, and particularly the eastern and northern margins and were enabled to examine in some detail the section at the north end of the mesa just south of Kayenta. The previous reports on the geology of the mesa, briefly noted below, and our own observations justify the assumption that the results obtained on the northern margin will hold for the whole area. As they are somewhat at variance with the earlier views it has seemed worth while to record them.

Previous Observations

In 1861 Newberry[2] recorded the first description of the southern side of Black Mesa, assigning the lower [Dakota (?)] coal-bearing rocks to the Jurassic on the basis of the associated plant fossils and the overlying beds to the Cretaceous on the basis of both fossil invertebrates and plants. What seems to be the Mancos shale of later reports is assigned a thickness of 250 feet, and invertebrates are listed which would be called today *Prionotropis woolgari* Mantell, *Inoceramus labiatus* Schlotheim, and *Gryphaea newberryi* Stanton.

Howell[3] in 1875 also noted the section of coal-bearing rocks near the Hopi pueblos on the southern margin of Black Mesa, describing the succession as 100 to 300 feet of cream-colored sandstone and shale resting on 300 to 500 feet of dark shale, resting in its turn on soft white sandstones of Jurassic age.

In 1910 Darton[4] quoted brief descriptions from Newberry and Howell, and assigned the rocks of Black Mesa somewhat indefinitely to Dakota and later beds.

In 1911 Campbell and Gregory[5] compared the coal-bearing rocks of Black Mesa with those of the region near Gallup, New Mexico, and described them as including the Dakota sandstone and probably the Mesaverde formation, with a thin Mancos shale between. They

[2] J. S. Newberry. *Report upon the Colorado River of the West, explored in 1857–58 by Lieut. J. C. Ives. Pt. 3, Geological Report:* 82–83, 129–131. 1861.

[3] E. E. Howell. *Report on the geology of portions of Utah, Nevada, Arizona, and New Mexico.* U. S. Geogr. Geol. Surv. W. 100th Mer. **3**: 279. 1875.

[4] N. H. Darton. *A reconnaissance of parts of northwestern New Mexico and northern Arizona.* U. S. Geol. Surv. Bull. 435: 54. 1910.

[5] M. R. Campbell and H. E. Gregory. *The Black Mesa coal field, Arizona.* U. S. Geol. Surv. Bull. 431. 1911.

suggested that the Mancos shale owed its small thickness, as compared with the Mancos shale of San Juan Basin, either to actual lack of material or to a progressive change in the upper part whereby sandstones appeared westward at lower and lower horizons. The thickness of the so-called Dakota is given as from nothing to 70 feet, the Mancos shale as 300 feet, and the Mesaverde as probably not exceeding 500 feet.

In 1917 Gregory,[6] in a description of a large region including Black Mesa, added much detail, and interpreted the section in the mesa as containing Dakota sandstone, Mancos shale, and Mesaverde formation. The so-called Dakota sandstone was accepted as ranging in thickness from a few feet to 300 feet or more and containing, in addition to the usual sandstones, beds of conglomerate, shale, and impure coal. The greater thickness was found on the western side of the mesa. The Mancos shale was shown to have a thickness of from 490 to 620 feet where complete sections could be measured, the thickness increasing from southwest to northeast. The Mesaverde formation was shown to vary much in thickness, owing to the fact that it is the highest formation over much of the mesa and has been eroded to a varying degree. At the northeastern prominence, Yale Point, the formation included 745 feet of sandstone and shale, with coal in the lowermost part and again in a zone above the middle, and a marine horizon 200 feet above the base. This thickness is probably near the maximum remaining on the mesa. Fossils cited in the three formations: from the so-called Dakota, various plants; from the Mancos, *Exogyra laeviuscula* Roemer, *Ostrea* sp., *Inoceramus labiatus* Schlotheim in the lower part, and *Prionotropis* sp. near the middle; from the Mesaverde, *Ostrea pellucida* Meek and Hayden, *Inoceramus proximus* Tuomey, and *Gervillia*, said to be of Montana age, in the marine zone at Yale Point.

Darton[7] in 1925 accepted for the rocks of Black Mesa Gregory's classification as Dakota sandstone, Mancos shale, and Mesaverde formation, quoting from Gregory the data given.

Reagan[8] in 1925 gave a brief general discussion of the geology of Black Mesa and the surrounding region. For the Cretaceous he used

[6] H. E. Gregory. *Geology of the Navajo Country.* U. S. Geol. Surv. Prof. Paper 93: 68–79. 1917.

[7] N. H. Darton. *A resumé of Arizona geology.* Univ. Ariz. Bull. 119 (Geol. 3): 143–155. 1925.

[8] Albert B. Reagan. *Late Cretacic formations of Black Mesa, Arizona.* Pan-Amer. Geol. **44**: 285–294. 1925.

the following divisions, based apparently in large part on the section near Kayenta: Dakota sandstone, seldom exceeding 120 feet in thickness. Tununk shale and sandstone, probably exceeding 240 feet and containing *Gryphaea newberryi* Stanton and *Exogyra columbella* Meek. Mancos shale, equivalent to the part of the Mancos of other authors above the Tununk sandstone and exceeding 500 feet in thickness. Mesaverde sandstone, 350 feet thick and containing many thick seams of coal. Lewis or Masuk shale, 20 to 30 feet thick. Pictured Cliffs sandstone, 25 feet thick. Zilhlejini coal formation, 200 feet thick, bearing fresh and brackish water fossils and forming the surface rocks over much of the central part of the mesa. The fossils named are *Ostrea glabra* Meek and Hayden, *Ostrea soleniscus* Meek, and *Modiola laticostata* White. Reagan's Zilhlejini formation is overlain by shales and sandstones and with them was said to be a possible equivalent of the Fruitland and Kirtland formations of New Mexico. All the later rocks were spoken of as of Laramie age. In a later article[9] Reagan briefly described again the Mesaverde of Black Mesa and figured the three species found in his Zilhlejini formation. The present writers have examined the section near Kayenta and believe that in the lower part of his section Reagan has confused slumped materials with those in place and that his Tununk division does not exist. Between the Dakota(?) and the so-called Mesaverde there is only one shale body, as correctly described by Gregory[10] for the nearby Lolomai Point, in the lower part of which occur the fossils assigned by Reagan to his Tununk shale. The remainder of Reagan's section is considered in a later paragraph.

Section near Kayenta, Arizona

As just stated above, the writers examined the section, except for the uppermost part of the coal-bearing rocks, in the margin of Black Mesa, 4 miles south of Kayenta and 4 miles east of Lolomai Point. A number of collections of marine fossils were made that offer a check on the older collections from the Mancos shale, and one from the coal-bearing rocks that indicates a greater age than usually assigned to them. The thicknesses given are only approximate but the relative order of the beds is assured, as the rocks are completely exposed in a

[9] Albert B. Reagan. *Extension of Cretacic Laramie formation into Arizona.* Pan-Amer. Geol. **46**: 193–194. 1926.

[10] H. E. Gregory, *Op. cit.*, p. 74.

steep slope at the locality where the examination was made. The section with its fossils is as follows:

SECTION OF CRETACEOUS ROCKS IN BLACK MESA, 4 MILES SOUTH OF KAYENTA, ARIZONA

Mesaverde formation of previous reports:

Sheer wall of massive reddish-brown sandstone capping the edge of the mesa and visible for many miles along it 250

Gray to yellow sandstone with minor shale and coal beds, not examined in detail 350

Massive buff sandstone, medium grained; no fossils observed 50

Platy buff, fine grained, thin bedded sandstone and gray shale, forming a weak unit. The sandstone layers yielded *Inoceramus deformis* Meek, *I. undabundus* Meek, *I.* aff. *I. stantoni* Sokolow, *Ostrea congesta* Conrad, *Ostrea* sp., *Anomia subquadrata* Stanton, *Cardium pauperculum* Meek, *Tellina* cf. *T. subalata* Meek, *Legumen* sp. (n. sp.?), *Mactra* sp., *Dentalium* sp. (n. sp.?), *Turbonilla* cf. *T. coalvillensis* Meek, *Turitella* cf. *T. whitei* Stanton, *Baculites* cf. *B. codyensis* Reeside, *Placenticeras* aff. *P. pseudoplacenta* Hyatt 75

Grit and fine quartz conglomerate, gray to yellow, resting on an irregular base; no fossils observed 20

Coal in two thin beds in carbonaceous shale 40

Massive yellow sandstone; no fossils observed 50

Mancos shale of previous reports:

Interbedded light gray soft sandstone and sandy shale forming a transition zone; no fossils observed 100

Dark gray to black shale, much of it flaky; very thin, discontinuous calcareous fine grained brownish sandstones at a few horizons above the middle. A layer at 300 feet above the base of the unit contained an abundance of *Prionotropis woolgari* Mantell of Meek, and a few individuals of *Ostrea* sp., *Anomia?* sp., *Mactra?* sp., and fish scales; one 250 feet above the base, *Prionotropis woolgari;* and one 200 feet above the base, *Globigerina* sp. 350

Light bluish-gray calcareous shale containing a few very thin bands of dark limestone; basal 10 feet sandy. At the top were found *Inoceramus labiatus* Schlotheim, *Ostrea* sp., *Globigerina* sp., and a large fish vertebra; at 120 feet above the base of the unit, *Ostrea* sp., *Inoceramus* sp., *Globigerina* sp., *Baculites gracilis* Shumard, *Metoiceras* sp.; at 20 feet above base, *Inoceramus labiatus* Schlotheim, *Ostrea* sp., fish scales; at 10 feet above base *Liopistha* (*Psilomya*) *concentrica* Stanton, *Gryphaea newberryi* Stanton; at the base of the unit, *Ostrea soleniscus* Meek and Hayden. *Inoceramus labiatus* was noted at many horizons in this unit but the crumbly shale matrix prevented collection 150

Interbedded thin, impure coal beds and gray sandy shale, a transition unit 10

Dakota (?) sandstone:

Brown to gray coarse sandstone above, coal and gray shale near middle, brown sandstone and conglomerate below 100

Morrison formation (McElmo of authors):

Gray-white to greenish-white sandstone and red and gray shales.

Age of the Deposits

The Dakota(?) sandstone of Black Mesa has yielded so few paleontologic data that one may say at best only that it is probably equivalent to the beds widespread in western Colorado, Utah, and western New Mexico, and now usually designated Dakota(?) sandstone to express the likelihood that it is not an exact equivalent of true Dakota sandstone and the possibility that part of it may be of Lower Cretaceous age and part of Upper Cretaceous age. There may also have been an interval between the deposition of these parts not now represented by sediments.

The shale which has been called Mancos contains an equivalent of the Benton shale only, and is but a small part of the typical Mancos shale of the northern San Juan Basin in Colorado. It is essentially the Turonian of the European classification. Fossils distinctive of the highest part of the Benton, such as *Prionocyclus wyomingensis* Meek and *Scaphites warreni* Meek and Hayden, were not observed by the writers and have not been reported by others, but this zone may well be represented by the relatively barren and probably nonmarine zone at the top of the shale and in the base of the overlying formation. The occurrence of *Ostrea soleniscus* Meek and Hayden and *Gryphaea newberryi* Stanton near the base of the so-called Mancos agrees with the known range of these species. *Exogyra laeviuscula* Roemer, reported in this zone by Gregory, is also in agreement. The presence of *Inoceramus labiatus* Schlotheim and *Metoicoceras* sp. at somewhat higher levels accords with their usual position and indicates that the lower fourth of the shale is equivalent to the Graneros shale and Greenhorn limestone of the Great Plains region east of the Rocky Mountains. A second fourth yielded no fossils. The zone containing *Prionotropis woolgari* (Mantell) of Meek, constituting the fourth above the middle, agrees with the lower part of the Carlile shale of the Plains (upper Benton), and, as noted above, there is still room for an equivalent of the remainder of the Carlile in the uppermost fourth. A shale formation corresponding closely in position and fauna to the so-called Mancos shale of Black Mesa is known in a belt that includes the Kaiparowits Plateau, the Colob Plateau, the western margin of the Wasatch Plateau, and the Coalville region of Utah.[11]

[11] E. M. Spieker and J. B. Reeside, Jr. *Upper Cretaceous shore-line in Utah.* Bull. Geol. Soc. Amer. **37**: 429–438. 1926. G. B. Richardson. *The Upper Cretaceous section in the Colob Plateau, southwest Utah.* This Journ. **17**: 464–475. 1927. H. E. Gregory and R. C. Moore. *The Kaiparowits Region.* U. S. Geol. Surv. Prof. Paper (In press).

The so-called Mesaverde formation has not yielded a large fauna. The fossils found by the writers in the 75-foot unit 110 feet above the base of the formation are of Niobrara age and the containing beds correspond to some part of the middle Mancos of San Juan Basin and are considerably older than the typical Mesaverde of the same Basin. They are Coniacian, in terms of the European classification. Gregory records from a similar horizon in his section at Yale Point[12] the Montana species *Ostrea pellucida* Meek and Hayden, *Inoceramus proximus* Tuomey, and *Gervillia* sp. It is the writers' belief that these are misidentifications of species belonging to the same fauna as those found near Kayenta. For the higher beds Reagan records, as noted in page 33, *Ostrea glabra* Meek and Hayden, *O. soleniscus* Meek, and *Modiola laticostata* White. *O. glabra* of Reagan is a simple type that might be a variant of the species to which it is assigned, but might equally well belong to some other simple species and means little for correlation. If the identification of *O. soleniscus* is valid, and the published figure certainly lends credibility to it, the containing beds (Zilhlejini formation of Reagan) are not younger than Niobrara, for the latest known occurrence of the species is with Niobrara forms in beds that correspond in position and fauna to the "Mesaverde" of Black Mesa. These beds, like the equivalent of the "Mancos," occur in the Kaiparowits Plateau, the Colob Plateau, etc. The writers suggest, though the published figure is not very clear, that Reagan's *Modiola laticostata* is *M. multilinigera* Meek of Colorado age. A collection made by Gregory (U. S. Geological Survey loc. no. 11642), labelled, "Chilchinbito, massive sandstone capping Black Mesa," and apparently not included in any published record, contains *Inoceramus stantoni* Sokolow, *Ostrea* sp., *Mactra* sp., and *Volutoderma* sp. (large, undescribed). This fauna, from the highest unit of our section and in or above Reagan's Zilhlejini formation, is of Niobrara age and would support the fossils reported by Reagan. It is the opinion of the writers, therefore, that not only the lower part of the so-called Mesaverde of Black Mesa but the upper part also is of Niobrara age, and that there is no warrant for correlating any part of it with the typical Mesaverde and later formations of San Juan Basin or with the units recognized in the Henry Mountains of southern Utah.

Conclusions

The Cretaceous section of Black Mesa resembles that of Kaiparowits Plateau, Colob Plateau, the western side of the Wasatch Plateau, and

[12] H. E. Gregory. *Op. cit.*, p. 78.

Coalville, Utah, rather than that of San Juan Basin or the Henry Mountains.

The lowest of the three major divisions, the Dakota (?) sandstone, is assignable only in a general way to a pre-Benton age.

The middle major division, the Mancos shale of previous reports, is of Benton age, and represents only a small part of the typical Mancos shale.

The highest major division, the Mesaverde formation of previous reports, is of Niobrara age, and represents a part of the typical Mancos shale, and is considerably older than any beds to which the name Mesaverde could be applied, even in an elastic usage of the term.

PALEOBOTANY.—*An* Anacardium *in the lower Eocene of Texas.*[1]

EDWARD W. BERRY, Johns Hopkins University.

The genus *Anacardium* contains 8 or 10 species of shrubs and trees in the existing flora. Outside of cultivation these are confined to the American wet tropics. The leaves are rather characteristic and the fruits are exceedingly so.

Saporta, long ago, proposed a form genus, *Anacardites*, for fossil leaves supposed to belong to the family Anacardiaceae, but which could not be referred with certainty to any of the existing genera of the family. About a score of species have been referred to *Anacardites*, but these, with the single exception to be noted presently, resemble those of genera such as *Mangifera*, *Anaphremium*, and *Spondias*, and are not like the leaves of *Anacardium* itself.

The exception mentioned is *Anacardites balli* Berry[2] from the Jackson Eocene (Fayette sandstone) in Brazos and Grimes counties, Texas. Although it can not be conclusively demonstrated, I believe that this form is closely related to *Anacardium*, and this identification is rendered more probable by the discovery of the seed described below.

In 1924 I described the silicified fruits of an *Anacardium* from the Oligocene of Peru, and these are practically identical with the existing Cashew nut. They are present in great abundance associated with other fruits and seeds at a locality known as Belen, about 6 miles southeast of Puenta Pariñas, Department of Piura, Peru, and I had the pleasure of visiting the locality and making additional collections during the summer of 1927. The Peruvian material shows in an un-

[1] Received November 23, 1928.

[2] E. W. BERRY. U. S. Geol. Surv. Prof. Paper 92: 177. *Pl. 62, fig. 7.* 1924.